Crosthwait

Indian Corn

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INDIAN CORN
(Zea mays)

PRODUCTION, SELECTION, PRESERVATION, AND GERMINATION OF ITS SEED, AND GENERAL PRINCIPLES OF PLANTING

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Introduction.

Indian corn has long been the mainstay of Illinois agriculture and at no other time has its importance been so great as at the present. A yield of 372,436,416 bushels in 1902 shows that it is no mean factor in the wealth of the state. The manifold uses to which corn is put would require a large volume for their description. First in importance is its use as a stock food. The vast business carried on at the stock yards of our large cities is essentially a traffic in "transformed corn." As a product for human consumption, corn holds an important place, though in that respect it is subordinate to wheat. New processes of preparation, however, are bringing out products that bid fair to rival wheat, some of them being difficult to distinguish from

wheat products. Only recently has a new breakfast food has appeared, made wholly of corn, which appears to be equal, in every respect, to the famous "shredded wheat biscuit", which it resembles. Another very extensive use to which corn is put is the making of alcohol and whiskey. The distilleries of Peoria are famous for the vast amount of liquor made there. Many attempts have been made to manufacture paper from the corn plant, but the efforts were not commercially satisfactory until within the past few years. A plant has recently been located at Kankakee for the purpose of making paper from the stalk and leaves of corn, on a large scale. Three grades of paper are made from the hard, outer part of the stalk, from the pith, and from the husks. The grade made from the pith is nearly equal to a fine grade of linen paper. Mattresses, baskets, mats, and pipes are other products of the corn plant.

From the pith is made a packing material, which is used between the armor-plates at and near the water line. If the hull is pierced, the water enters and causes the packing to swell up, thus stopping the leak. Several battle ships of the United States are protected in this way. Where coal and wood are high in price, and corn is low, the last mentioned is sometimes used as fuel. One hundred bushels of ear corn are considered equivalent to one cord of hard wood, and three tons of cobs are considered equivalent to one ton of hard coal. From the starchy part of the kernel is obtained corn starch and laundry starch. Sirup and sugar, also, are products of the starchy part. "Corn oil" is obtained from the germ and is used for illuminating purposes; for dressing wool, and ~~for~~ making soap.

Indian corn, or maize, botanically known as Zea mays, belongs

to the grass family, Gramineae. In the grass family are found the grasses and cereals, and even the tall canes and bamboos.

The number of species in the grass family is uncertain because of the great number of synonyms; but Hackel, in "The True Grasses", estimates that there are about 3,500 well defined species. Grasses are found in every zone, the greater number of species being in the Torrid Zone and the greater number of individuals being in the Temperate Zones.

Several classifications have been proposed for Indian corn, Zea mays being of so general application that it is of no use in distinguishing the various kinds of corn. Dr. E. Lewis Sturtevant has proposed the following very satisfactory classification:

Zea tunicata, the primitive form.
Zea everta, the pop corns.
Zea indurata, the flint corns.

Zea indentata, the dent corn.
Zea amylacea, the soft corn.
Zea saccharata, the sweet corn.
Zea amyleasaccharata, the starchy sweet corn.

A more common classification is the following:

Dent corn.
Flint corn.
Soft corn.
Sweet corn.
Pop corn.

The origin of Indian corn is not certainly known, but it is generally admitted that it is a native of southern North America or of Central America. At the time of the discovery of North America corn was cultivated from Maine to Chili. It is supposed by some that the peculiar coyote corn, which grows wild in tropical America, is the original corn plant. In general the structure of this plant is similar to that of our common corn but the ears are only about two inches long and contain but four rows

of kernels. In addition to the outer husks, which envelop the entire ear, the individual kernels often have a separate covering similar to that on the kernels of our common pod corn. In ordinary field corn these secondary envelopes are undeveloped and constitute the chaff found at the bases of the kernels. Others think that they see in our common teosinte a more remote ancestor of the maize plant. Whether the original maize plant is still growing or not, it is certain that the corn of the present is very different from what it was in the early stages of its development. It was undoubtedly then a much branched plant, bearing little ears or clusters of kernels upon its many branches. Evidences of this primitive habit can be seen in the corn of today. The throwing out of suckers or tillers is simply a reversion toward the old habit of branching, while the development of kernels, or e-

er of small ears, in the tassel or at the tips of the tillers, is a reversion towards the habit of bearing ears at the tips of the branches. On page 105 is a photograph of a corn plant found by the writer in one of the experiment plots of the Illinois Experiment Station in the summer of 1902. In the same photograph is shown a sucker ear with secondary ears at its nodes. On page 106 are shown the same specimens with the husks and leaves removed. The complete plant bore thirty-two ears in all, the greater number being small and undeveloped. The sucker ear bore in addition to the terminal ear six secondary ears on its shank, making seven ears borne at a single node of the parent plant. The ear itself is probably an aggregation of branches, each of which bore a two-ranked series of flowers. In the process of development the small peduncles

bearing the individual flowers would shorten, thus bringing the flowers close to the common branch or rachis and forming a kind of spike. These spikes would, in turn, be brought closer together by the shortening of their internodes, and would coalesce, forming a central compound rachis, the cob. Around this would be crowded the individual flowers. In time, a division of labor would take place; some of the flowers producing the stamens or male organs, and others producing pistils or female organs. As the uppermost position was best suited to the dissemination of the pollen, the highest clusters of flowers would assume the function of producing pollen, and the others would produce the ovaries. Finally, we have the tassel surmounting the plant with a number of small ears at the nodes. By careful selection a plant is produced, bearing but one or two ears and

yielding as as much or more grain as the entire branched plant yielded.

In the following pages are brought together a few facts concerning seed corn and the planting of corn. A fairly representative bibliography is given, which will be helpful to those who may desire to make a study of the maize plant.

Part One.
General.

Chapter I.
Production of Seed Corn.

1. General Principles.—In the production of seed corn, it is of primary importance to produce seed of high germinating power and of absolute purity as regards variety. Given a start of good seed it is possible not only to attain the above, but to greatly improve a variety, or even to originate a new strain. Several topics of general application in the raising of seed corn will now be discussed.

(a) Planting.—For the best results in seed production the soil should be amply provided with plant food. If the soil is deficient in nitrogen, the plant will be stunted and will not possess the vigor

necessary to bring the seed to perfection. On the other hand if the nitrogen is greatly in excess particularly in comparison with the other elements of plant food, the growth will be too luxuriant, with a consequent weakening of the plant and a liability to disease.

There should be a sufficiency of phosphorus in the soil, as this element is essential to the formation of the seed. About one-fifth of the ash of the corn kernel is phosphorus.

Potassium is another essential element of plant food in which the soil is sometimes deficient, although this is less frequently the case than is the case with nitrogen and phosphorus. Potassium enters quite largely into the composition of the ash of the kernel, of which it is approximately one fourth. Potassium constitutes about two-thirds of the ash

of the stalk and a deficiency of this element results in a much weakened stalk.

The three elements of plant food mentioned are the only ones of which there is likely to be a deficiency and are the ones that may have to be supplied by means of manures or artificial fertilizers. It is not considered good farm practice, however, to purchase commercial fertilizers for their nitrogen content, when nitrogen can be so much more economically supplied by legumes. Barn-yard manure should be applied in the fall, winter, and early spring. If phosphorus is needed, part of it should be applied in a form immediately available to aid the plant in its early growth but the remainder may be applied in one of the less available but cheaper forms, such as ground bone or tankage, which will become available for the later growth of the plant.

A more economical plan is to apply rock phosphate, which will become available gradually, requiring several years to all become available. If this is done, it will soon be unnecessary to use the higher priced phosphorus fertilizers. Potassium may be best applied as muriate of potash or as kainit.

With the soil well stocked with plant food, the next important thing is the preparation of the soil. If this is not properly done the plant can not appropriate the food from the soil in sufficient quantity to make a good growth. The ground should be plowed when it is just moist enough to crumble nicely and should be worked until it is as fine as a garden bed. If the ground is plowed in the fall, the disk-harrow and the smoothing-harrow will put it in good condition in the spring. If it is plowed in the

spring, the smoothing-harrow will be sufficient, if the soil is in condition when plowed. Whatever plan is followed, the seed-bed must be put into good condition, if the best results are to be attained. The corn should be carefully planted so as to obtain a good stand of two stalks to the hill. It is a good plan to plant more than the number wanted, and to thin to the desired number, taking out the weak plants. With careful and frequent cultivation, a large yield of excellent seed corn should be obtained.

(b) Crossing.- Corn is a plant which is naturally fertilized by cross-pollination; that is the nucleus of the egg cell and the endosperm nucleus in the female flower on one plant are made fertile by the generative nuclei from the pollen of another plant. This interesting process will now be briefly considered.

The staminate flowers, which constitute the inflorescence known as the tassel, bear a great number of pollen grains in their anthers. Each anther contains as many as 2500 pollen grains; and as each flower contains six anthers, there would be 15000 pollen grains in a single flower. The anther is morphologically double, Each lobe has a lateral pore at the free, downward pointing end, out of which the pollen falls when the anther is shaken. A light breeze is sufficient to shake out the pollen and to carry it to the silks protruding from the husks of neighboring plants. If the breeze is too light to carry the pollen to other plants, it is too light to shake it out of the anthers.

The pistillate flowers are clustered upon the cob and are protected by the husks. The long slender style grows out from the summit of the ovary and protrudes from the husks when ready to re

ceive the pollen. Upon the sur-
face of the style are numerous
hair-like processes, which are e-
longated epidermal cells. The en-
tire style is morphologically dou-
ble and has two vascular bundles
running its whole length. The ova-
ry, while quite young, is envelop-
ed in several bract-like bodies, through
which it bursts as it enlarges. While the
ovary is in its early stages, a
spherical mass of loose cellular
tissue begins to develop within it
at the lower end. This is called
the nucellus. From the base of
the nucellus two coats grow up
and envelop it. The inner coat
is called the tegmen and the out-
er one is called the testa. The
nucellus and its coats consti-
tute the ovule, which develops
into the seed. At the free end
of the ovule is a small open-
ing, the foramen, where the
coats have not completely cov-
ered the nucellus. This opening

becomes closed in the mature seed and is called the micropyle. Near the micropylar end of the nucellus a cell begins to enlarge. This is the archesporial cell, from which the embryo sac is developed. As this cell enlarges, its nucleus divides, and the resulting nuclei separate, one passing to one end of the embryo sac and the other to the opposite end. Each nucleus again divides making two nuclei at each end of the embryo sac, and this division is followed by a third whereby there are four nuclei at each end. One nucleus of each group of four then passes to the central part of the embryo sac. These two nuclei, the "polar nuclei," coalesce and form the endosperm nucleus or definitive nucleus. The three nuclei at the micropylar end of the embryo sac become surrounded by cytoplasm, forming definite

cell walls are formed. These naked cells are called the "egg apparatus". Two of these cells are known as the synergidae or "helpers", and the other one is called the egg cell. The three nuclei at the opposite end of the embryo sac are organized into cells called the "antipodal cells". The development of the contents of the embryo sac now ceases until fertilization takes place.

When a pollen grain falls upon a receptive silk, it is held by the hair-like processes upon the silk and also by a sticky substance with which the silk is covered. The nucleus of the pollen divides, one of the new nuclei being called the vegetative nucleus. The other nucleus again divides into the generative nuclei. When the pollen becomes adherent to the silk, the vegetative nucleus initiates the development of the pollen tube, which enters the tis-

sue of the silk and grows toward the ovary. While the ovule has been developing, it has gradually changed from its erect position in the ovary, by doubling upon itself until the foramen or micropyle points outward and downward. When the pollen tube enters the ovary it passes down the anterior side of the inverted ovule, through the tissue of the testa or outer coat. Entering the foramen it makes its way to the egg apparatus. In the mean time, the generative nuclei have proceeded down the pollen tube. They now break through the tip of the pollen tube and one of them unites with the nucleus of the egg cell, while the other passes on and unites with the endosperm nucleus. This is the process known as double fertilization. The fertilized egg cell now develops into the embryo, which differentiates

into the radicle or embryo root, pointing toward the micropylar end of the ovule, and the plumule or embryo shoot, pointing in the opposite direction. The fertilized endosperm nucleus develops into endosperm, which displaces the substance of the nucellus to such a degree that there is no part of it left but a very thin layer of compressed cells and the very thin tegmen or inner coat, the testa having disintegrated. The wall of the ovary is crowded to a thin transparent coat which closely adheres to the seed. The outer layer of the endosperm is called the aleurone layer, and it is this layer that contains the coloring matter of the kernel.

The mode of pollination in corn, whereby one plant receives pollen from another plant gives rise to many variations in the product of succeeding generations, as a result of the

mingling of the characteristics of different individual plants. By careful selection corn can be produced having the good characteristics of different individuals. In addition to the variations arising among the plants of the same variety there is the possibility of originating new varieties by crossing individuals of different varieties, thus securing the good qualities of each.

(c) Inbreeding. - Inbreeding, in Indian corn, is the fertilization of the female sex cells of a plant by the generative nuclei of its own pollen. This seldom occurs in nature, as the wind carries the pollen to other plants. Some work has been done in the inbreeding of corn by hand pollination, but the results have shown that it is not practicable as the variety rapidly deteriorates if the process is continued for several generations.

(d) Xenia. - Xenia, or the immediate effect of pollen, has long puzzled our botanists. As it is so evident in maize and as it is in connection with maize, that a solution has recently been offered, a few words concerning the phenomenon may not be out of place in this connection.

When two varieties of corn are crossed, for example, when the pollen from a red variety fertilizes a white variety, there is a union of the characteristics of the two varieties. When the kernels containing the hybrid embryos are planted they produce some red, some white, and some mixed grains, as would naturally be expected. What has so long been a mystery, however, is that in the same season that the crossing is done, red kernels or mixed kernels appear in the ear of white corn. It could not be understood how the fertilization of the egg cell could produce any effect outside of the embryo

The discovery, in 1899 of the phenomenon of double fertilization offered an explanation of the puzzling phenomenon. As has been explained above, the endosperm nucleus is fertilized at the time the egg cell nucleus is fertilized; and furthermore that the endosperm develops at once, composing mainly the whole of the kernel. It has been mentioned also that the aleurone layer contains the distinctive coloring matter of the kernel. The coats lying outside of the endosperm are very thin and practically transparent, so that the coloring matter of the aleurone layer is plainly visible. Any variation, then, that may occur in the endosperm will be evident the same season that the cross is made.

(e) Mendel's Law:- Man, in his study of nature, finds that some of her secrets are easily discovered; some are yielded to him after much painstaking effort; an-

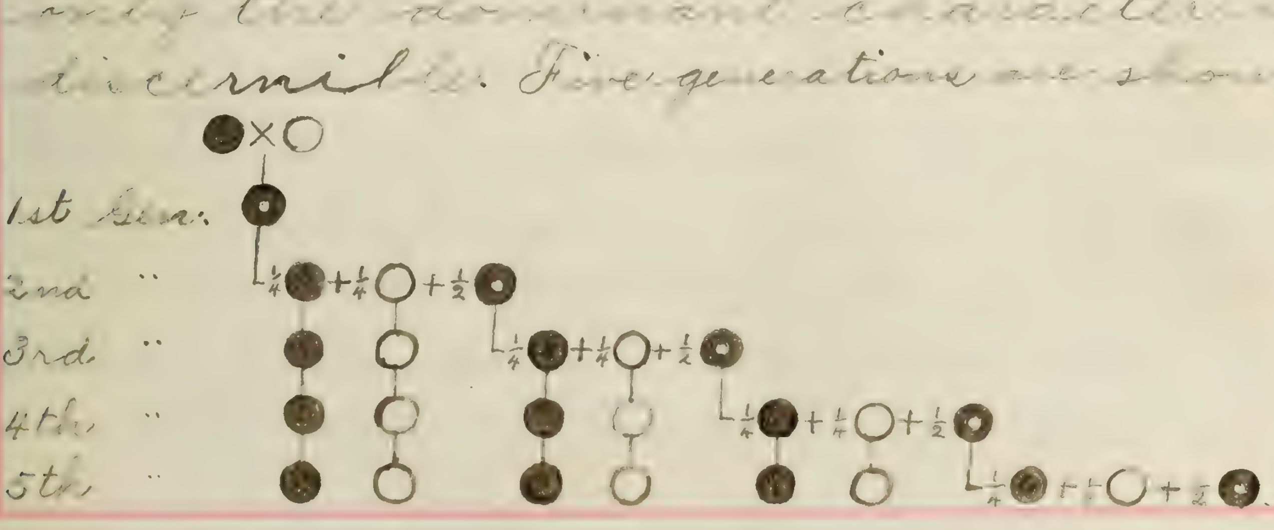
his pupils, while still others seem to evade him, no matter how laboriously he may strive to search them out. In this last class may well be placed the laws of heredity. Almost the only results attending the efforts of the many thoughtful men who have tried to solve the problems of heredity have been piles of rubbish which have obscured their own vision. With the closing years of the nineteenth century, however, a ray of light began to shine, and hope in the final solution of the vexing problem has been revived.

In the year 1900, Professor de Vries published a short account of some experiments he had been carrying on in plant breeding for several years. The results obtained were of great value and the world of science was at once intensely interested, and his findings were almost immediately corroborated by Tschermak and Correns. As the work of Correns was carried on partly with maize, the

subject is especially relevant in a discussion of seed corn. What was particularly surprising in de Vries' article, however, was his statement that his results were corroborative of principles laid down thirty-five years before by Gregor Mendel, then Abbott of Brünn. After years of careful experimentation, Mendel had published his conclusions in 1865 but, for some inexplicable reason, his work was not noticed and it had been hidden until rediscovered and announced by de Vries. Tardy recognition has at last been accorded the obscure investigator, in that the principle of heredity discovered by him is now called "Mendel's Law." A brief consideration of the simpler details of this law will now be given but he who wishes to be fully informed on the subject must refer to the works of the above mentioned investigators and of others who have since taken up the subject.

Mendel's law may be stated as follows: in crosses where not even intermediates are rarely ever produced; that is, when there is no visible mingling of characters, the offspring arising by breeding these hybrids with each other, are broken up into the original parent forms according to a fixed numerical ratio. The more characters there are involved, the more difficult it is to trace out the numerical relation. For this reason we shall consider a case in which but one pair of characters is involved. In the crosses to which Mendel's law applies, one of a pair of characters is always stronger than the other and prevails over it when the two are combined. This character Mendel called the dominant character, while the weaker one is called the recessive character. The following diagram illustrates the manner in which the characters are distributed in crosses.

successive generations. Field corn and sweet corn will be taken as examples. In crosses between these two varieties, the starchy endosperm character of the field corn prevails over the sugary character of the sweet corn and is therefore the dominant character. The distinction between the two is readily seen as the wrinkled appearance of the sweet corn contrasts strongly with that of the field corn, especially if a flint variety is used. In the diagram, ● represents the dominant character of the field corn, ○ represents the recessive character of the sweet corn and ◉ represents the union of the two characters, in which, however, only the dominant character is discernible. Five generations are shown.



As shown in the diagram, the first generation resulting from the crossing of the two pure varieties is composed wholly of individuals possessing both the dominant and the recessive characters but with the dominant prevailing; that is, with nothing in the appearance of the corn to distinguish it from the pure bred field corn. If these hybrids are self fertilized a distinct breaking up is evident in the next generation, the second from the original crossing. One fourth of the individuals are pure dominants, one fourth are pure recessives, and one half are dominant recessives with the dominant character prevailing; that is, in this generation three-fourths of the individuals cannot be distinguished from the field corn, and one-fourth cannot be distinguished from the sweet corn. If the individuals of this generation be self-fertilized, the individuals of the third genera-

tion will break up as shown above; that is, the pure dominants will produce pure dominants, and the pure recessives will produce pure recessives; but the dominant-recessives will break up as the dominant-recessives of the first generation did; namely, into ¼ pure dominants, one-fourth pure recessives, and one-half dominant-recessives. So long as self-fertilization takes place, this process will continue during succeeding generations, with the proportion of dominant-recessives of the entire generation gradually diminishing, but the manner in which each dominant-recessive breaks up in its offspring remaining the same. The practical thing in this discovery of Mendel's is that after the second generation pure recessives can be selected with certainty, and after the third generation pure dominants, as well, can be selected with

equal certainty. To obtain the exact numerical relation given above would require a very large number of individuals, as the problem is one of chance.

Now that a law has at last been stated and proved, efforts are being made to formulate a theory to explain the causes which result in this law. It is agreed by the investigators above mentioned, that in pollen grains and in egg-cells a single individual germ cell bears but one of the alternative varietal characters; that is that it is pure in respect to the pair of characters to which the law is applied. If this hypothesis be true, and if, on an average the same number of pollen grains and of egg-cells transmit each of the characters of the pair considered, the results will be such as are asserted by Mendel's Law.

Let ♂♂, represent pollen grains

containing dominant and recessive characters respectively, and let (●♀ ○♀) represent egg-cells containing dominant and recessive characters respectively. Only the following combinations can occur in crossing:

●♂ × ●♀ = ●.
○♂ × ○♀ = ○.
●♂ × ○♀ = ◉.
○♂ × ●♀ = ◉.

It is evident that such a theory will explain Mendel's law but a careful study of the germ cells is necessary to prove whether or not the theory is correct. Several American cytologists, in both botanical and zoological lines, have begun upon the problem, and the reports of progress thus far made indicate that the proof of the correctness of the theory is likely to be obtained at no very distant day.

2. Improvement of Varieties.

(a) Improvement of Physical Character.

The improvement of the physical characters of corn has been the aim of the corn grower from time immemorial. The difference between the wild corn of Mexico and that cultivated by the Indians at the time of the discovery of America was greater than the difference between the latter and the best variety of the present day. How long this improvement had been going on we have no means of determining. Every one who raised corn would naturally save for seed what he considered the best, and this would result in a gradual advance in quality and also in quantity per unit area. The size of the ears would very likely be the first character selected. A large ear is more easily harvested than several small ones. As the larger ears would be found on the plants

having the fewest branches or tillers, a plant with fewer branches would result until finally an unbranched plant bearing one or two large ears is produced. Probably the next character selected would be the position of the ears upon the stalk. If two ears were alike, but one was convenient to reach while the other was either too high or too low, the convenient ear would be selected. In this way one characteristic after another would be fixed. The corn plant is very responsive to selection, and the grower must have definitely in mind what he desires and must persevere until the desired characters become permanent. Patience and fixedness of purpose are essential to success in any line of plant breeding, but well directed and persevering effort will be amply rewarded.

b. Improvement of Chemical Characters.

Not only may the physical char-

-acters of corn be modified, but the chemical characters, as well, may be changed, to a greater or less degree, by careful selection. The problem in this case however is more complex than that just discussed. Here it is the chemical constitution of the kernel that must be considered, and the skill of the chemist combined with the apparatus and chemicals of the laboratory are absolutely essential. While every corn grower engages more or less in the improvement of the physical characters of corn, comparatively few are engaged in the improvement of its chemical characters. Scarcely anything had been done in this line of plant breeding until within the last few years. However, careful investigators have taken up the work, and enough has already been accomplished to show that there are great possibilities in this line of experimentation.

Corn is so extensively used as a stock food that any change in its feeding qualities is of primary importance. Used alone it is not a perfect food on account of its low protein content, the nutritive ratio ratio being about one to eight (1:8). It is evident that it is a great fat producer, and as such it is extensively used by stockmen especially in the production of pork. However, the quantity of fat produced by an exclusive diet of corn is too great in comparison to the quantity of lean meat produced to make a wholesome food for man. It is necessary to combine other food stuffs with it having a narrower nutritive ratio, in order to balance the ration. Furthermore, the quality of the fat produced by corn alone is not of the best. American pork has been debarred from some foreign countries on account of its inferior quality, at least this was the reason alleged. Attempts have

been made and are now being made to narrow the nutritive ratio of corn. Much has already been accomplished to encourage continuation in this line of work. By chemical analysis the proximate composition of a large number of ears is determined, and those are selected for seed which show the highest protein content. From the product of these ears another selection is made and the best ears are again used for seed. By continuing this selective process for several generations a marked improvement in the protein content is noticeable. The The low protein corn is gradually "weeded out" and that only is preserved in which variation is toward a higher protein content. It is confidently expected that, in this way, varieties of corn may be bred which will constitute balanced foods for the various needs of the stock.

Not only will corn become a more satisfactory stock food, but

it will be of much more value for human consumption. The low protein content is the principal objection to corn, but this can all be remedied by the breeding of high protein corn.

In a manner similar to the above process, low protein corn is also being bred. Low protein is correlated with high starch, which makes corn more valuable in the manufacture of starch and glucose. It is also of more value in the manufacture of alcohol because of the larger amount of sugar obtainable from the starch.

The oil, which is found principally in the germ, may also be varied by selection. Corn oil has many uses today and it a valuable by product in the manufacture of starch, glucose and alcohol. Considerable progress has been made in this direction also.

It is very evident that a simple variety of corn may be varied

in several directions – till the differences are so great as to demand different variety names. This is already the case with at least one variety. Burr's White corn has been bred in four directions at the Illinois Agricultural Experiment Station and as a result four new varieties have been produced. They are known as Illinois High Protein, Illinois Low Protein, Illinois High Oil, and Illinois Low Oil. In this work, different correlated combinations may be made. For example: a variety may be bred for low protein and high oil. This would be valuable to the manufacturer because of the high starch content from which to derive his principal product, and because of the increased output of oil as a by-product. It is very probable that in a few years our varieties of corn will be named in accordance with their chemical characters, and you can choose the variety best suited

to his requirements.

3. Breeding Plots: In order to successfully improve a variety of corn, some system of planting should be adopted which is convenient and accurate in keeping a record of the particular ears planted. There are two general systems; the "block" system in which each ear is planted in a small square and the "row" system in which each ear is planted in a row. The latter is the more desirable of the two systems as it is simple and convenient.

A diagram of the plot should be kept and a complete record of the ears planted should be made. It is thus possible, at any time, to look the record of the characters and performance of any particular ear. If this record is properly kept, it will become valuable as a reference as time goes by.

A small plot should be kept in which the ten best ears every

be planted each year. The best of the remaining ears should be planted on a larger plot to raise seed for field use or for the seed corn market. The extent to which a record of individual ears should be kept depends upon the extent to which the grower is going to enter into the seed corn business.

Every farmer should begin to raise his own seed corn, starting with a small quantity of the best seed he can obtain, selecting some standard variety that is suited to his conditions. He can soon have an abundance of high grade seed corn at but small expense of money or labor.

Chapter II.

Selection of Seed Corn.

1. Principles Controlling Selection.- In the selection of seed the essential of first importance is that such seed be chosen as will have sufficient vigor to germinate and to give the young plant a good growth until it has thrown its roots out into the soil and is able to procure its sustenance therefrom. With this in view seed should not be selected from stunted or diseased plants. After all possible care has been taken, it often happens that the seed is not of the highest grade. The only way to be sure of the vigor of the seed, is to test its germinating qualities shortly before planting time.

A second essential is that the seed be pure or free from mixt-

with other varieties. For a plant pollinated as corn is, one must be very careful to avoid mixtures of varieties. The minute pollen grains of corn can be carried a long distance, depending upon the dryness of the air and the velocity of the wind. In order to be safe, the field should be at least eighty to one hundred rods away from other varieties.

The breeder of standard seed must have definitely in mind the exact thing for which he is seeking and he must not deviate from his ideals. Nothing will be accomplished by selecting several years for one character and then selecting for another and forgetting the first.

2. Time of Selection.- The formation of the embryo begins quite early in the development of the seed, and it is fertilized and capable of germinating when taken from the plant a considerable time before the seed is mature. Experiments have shown that the seeds of cereals gath-

seed before the starch is formed, and while the juice of the kernel is thin and watery, will often germinate. It is evident, however, that the more immature the seed is, the less food will it have stored up for the nourishment of the germinating embryo. It has also been found that seeds not quite ripe germinate somewhat more quickly than those fully ripe. It is not probable, however, that the gain in time of germination will offset the loss of available food material stored up as starch. Some farmers make a practice of going through their fields before the ears of corn are mature and selecting their seed corn. This practice is not so common as it formerly was and it is very doubtful if it is worth the trouble. The most satisfactory time to select seed corn is probably just after it has matured and before the elements have injured it in any way.

3. Manner of Selection.—In select-

ing seed for the general crop, it is, ordinarily, sufficient to select the ears from the crib as the corn is being husked or it may be selected later if the corn is well protected from the elements. For careful breeding, however, more care must be taken. As the ear is but a part of the plant, the characters of the entire plant should be considered. The height and size of the stalk, the extent and character of the foliage, the character of the tassel, the position of the ear on the stalk and even the character of the root-system should receive attention if the best results are to be obtained. None of these characters can be determined if the ears are selected from the crib. Two selections should be made,- a preliminary one in the field and a final one in the seed house.

In the preliminary selection full notes should be taken of all

stalks from which ears are selected; those ears, only, being selected which a cursory examination points out as of probable value. Each ear should be tagged and numbered to correspond with the number of the description of the stalk from which it is taken. The ears selected should be stored in the seed house to await the final selection.

The final selection is made on the basis of the characters of the ear and of the entire plant. Each ear is carefully studied as a whole with reference to its size, shape, filling out of butts and tips, arrangement of kernels, color and any other characters which the breeder may wish to consider. A careful study is then made of the individual kernels, their shape, size, uniformity, and indentation. If the chemical characters also are to be studied, an analysis of the kernels will be made in addition to the physical characters mentioned. All

characters are carefully recorded and the ear conforming most closely to the ideal in the mind of the breeder is selected as the best ear. Then the other ears are selected in the order of their excellence as compared with the ideal ear. When the ears so far differ from the standard as to prohibit their use as the best breeders, they are reserved for field use or for the trade. A full record of the ears selected for the breeding work and also of the plants from which they came is entered into the permanent record book, and the seed is stored away to await the next growing season.

4. Seed from Different Parts of the Ear.- Quite a little discussion has taken place as to the relative effect of planting kernels from different parts of the ear. Some growers discard the kernels on the butts and on the tips, claiming that they make a poorer yield of corn than those from the rest of the ear. Others plant all of the kernels,

claiming that there is no appreciable difference in the results. Some of our Experiment Stations have undertaken to settle the question by experimenting for a series of years. They vary in different years and at different stations, but they vary so little that the question may be considered settled. Averages of tests for as many as nine years indicate that there is very little difference in the yields from seed selected from different parts of the ear, that is from butts, middles, or tips. Apart from the question of yield, however, there is a good reason for discarding the kernels from the butts and tips in ordinary planting. Planting is usually done with a corn planter, which may be regulated to drop a certain number of kernels in each hill, provided the kernels are of fairly uniform size. The kernels from the butts and tips being small and irregular, cannot

the planter to drop more kernels into some hills than into others.

5. Seed from Other Localities.- The question is often raised as to the advisability of planting seed corn raised at a considerable distance from where it is to be planted. In this age of cheap and rapid transportation facilities it is a small matter to send seed across the continent. Here again experimenters have essayed an answer. It is found that it is not always best to plant seed raised at a distance especially if raised in a different latitude. Corn that has been grown for years in the same neighborhood has become thoroughly adapted to the soil and climatic conditions of that place. A change in any of the conditions prevailing will produce a change in the corn plant and the greater the change in the conditions, the greater the change in the plant. As soil conditions are apt to differ in

a very small area, they should be carefully considered. The climatic conditions are less variable, similar conditions prevailing over larger areas. Temperature is mainly dependent upon elevation and latitude. Moisture conditions are dependent upon elevation, the direction of the prevailing winds and the character of the soil. All these conditions may well be taken into account when a change of seed is to be made. There are at many reliable corn men engaged in the production of high grade seed corn that there is no necessity for sending any great distance for seed. In general, good seed corn can be obtained which has been raised under conditions of soil and climate similar to those with which the farmer has to contend.

Chapter III.

Preservation of Seed Corn.

1. Methods of Drying.— As the presence of moisture is one of the principal conditions requisite to the germination of seeds, it is the absence of moisture necessary to the preservation of seeds. Absolute dryness is not necessary but the seed must contain a minimum quantity of moisture. The problem for the seed corn grower to solve is to find the best means of securing and retaining the proper dryness. The drying of seed corn by artificial heat is practised by some seedsmen. The seed house should have tight walls, single or double, preferably the latter. Provision must be made for controlling ventilation. Heat may be provided in any convenient way. A small stove and

…ured by an artificial process is convenient and inexpensive. Another method is to have the stove in a cellar beneath, and to let the heat come up through openings in the floor, or through a slat floor. As soon as the corn is gathered it should be stored in racks in the seed house. Enough fire should be kept to keep the air in the room dry and the corn will rapidly dry out. When the weather is damp and cool, more fire is necessary.

Some seed corn growers object to the curing of seed corn by artificial heat, claiming that the process is unnatural and weakens the seed. If artificial heat is not relied upon, the seedhouse should be so built as to allow an abundance of fresh air to be admitted on dry days, and so as to allow of being closed air tight on damp days. It is very probable that in damp falls, at least a little artificial heat would be helpful.

2. Methods of Storing.— There is probably no more satisfactory way of keeping seed corn than in racks or tiers in the drying house as mentioned above. If this method is followed, the corn can be kept under nearly perfect conditions as to moisture and temperature. If the weather is damp or excessively cold, a little fire will correct these adverse conditions. If a seed house of the above type is not at hand, the corn must at least be stored where it will not be subjected to too sudden and great changes in moisture and temperature. Corn can stand a wide range in the amount of moisture and the degree of heat, but it is probably weakened thereby. If the temperature suddenly falls far below zero, as it sometimes does, and if the corn contains considerable moisture, there is great danger that the vitality of the seed may be injured.

Chapter IV.

Germination of Seed corn.

1. General Principles of Germination.

There are three conditions absolutely essential to the germination of seeds. They are moisture, heat, and oxygen. The amount of each required varies in different plants, but each plant has its optimum. The minimum and maximum of these conditions are quite widely separated in plants.

It is essential that the tissues of the seed absorb water in order that the nutritive materials may be dissolved and cellular activity take place. The amount of water giving the best results in germination varies considerably for different species. The seeds of many aquatic plants germinate when immersed in water.

The seeds of most agricultural plants, however, germinate best with a moderate amount of moisture. If there is too much water present, the germination is retarded, and the seeds themselves are likely to rot. These bad effects are due mainly to the lowering of the temperature and an insufficient supply of oxygen. The moisture content of ordinary soil is about right when it is just dry enough to crumble when turned by the plow.

The practice of soaking seeds in water before planting them is sometimes resorted to for the purpose of hastening germination. This would seem to be a rational procedure, as the hard, outer coats of the seed would be quickly softened, and the embryo would receive sufficient moisture to cause it to begin developing at once. Some investigators claim that the above course is beneficial, while others claim that it is not beneficial and may be injurious. The latter claim

that if, when seeds are put to soak, other seeds of the same lot are planted under favorable conditions, there will be no appreciable difference in the time of germination of the two lots. The question is not settled as yet, but it is likely that the difference arises from the fact that different kinds of seeds are used and that the length of time seeds are soaked is an important factor. If seeds are kept in the water too long, injury will result, the vitality of the seed being entirely destroyed in some instances.

The germination of seeds is dependent upon temperature, also. The range of temperature is quite wide for the seeds of different species, and even for the individual seeds of the same species. Some seeds will germinate at a temperature almost down to the freezing point, while others will germinate considerably above 100° F., the cocoanut germinating best at about 120° F. Our common agricultural plants will

rarely germinate below 40°F. or above 115°F. Each species has its optimum temperature for germination. The seeds of plants native to temperate regions germinate at a lower temperature than do the seeds of plants introduced from tropical regions. The optimum varies in a like manner. Our northern cereals, wheat, rye, and oats germinate best at about 84°F., but corn germinates best at about 88°F. Whether germination more satisfactorily proceeds, when the temperature remains steadily at the optimum or when it varies somewhat above and below the optimum with the average temperature the same as the optimum, is still a mooted question. Of one thing we can be positive; that is, that under natural conditions there is uniformity of temperature at some optimum. It is at the optimum temperature that cellular activity is most active in the embryo. As the tem-

perature varies from the optimum either above or below, the activity of the protoplasm is retarded; and if the change in temperature is great enough, cold rigor or heat rigor occurs and all activity ceases. If this condition lasts too long, the tissues fail to revive and the result is death to the organism. If the change is not too great nor too long continued, cellular activity will be resumed on the return to favorable conditions. It is in this way that regermination takes place.

The third requisite to normal germination is free oxygen. Germination will sometimes begin in the absence of free oxygen but it is abnormal and soon ceases. Oxygen is necessary to the respiration process which is necessary to germination. Not until this process has begun, can the hydrolytic process begin whereby starches, fats, and insoluble albuminoids are transformed into prod-

into which the developing embryo can rest.

The effect of light upon germination varies in different species. Some seeds seem to germinate equally well in the light or in the dark. Such seems to be the case with the seeds of the majority of our agricultural plants. Some seeds germinate better if covered so as to exclude the light. A few seeds, of which the heaths are an example, germinate better when uncovered.

2. Methods of Testing.- It is very desirable that a test be made of the germinating power of seeds before the time comes for putting in the crop. So much depends on the quality of the seed, that only that which is of a high grade should be used. The test should be made long enough before planting time to allow time to get other seed if necessary.

There are two general methods of testing seed; out-doors in the soil and in-doors in sand or some other convenient material. As seed corn is usually tested during the winter months, the outdoor method is not feasible and some in-door method must be adopted. This, however, is no drawback, as the indoor method is more reliable, on account of the better control of the conditions favorable to germination. For the medium in which to place the seeds, soil, sand, or sawdust may be used. In testing seed corn an ordinary dinner plate filled with sand is very convenient. The sand is wet thoroughly and the plate is tilted several seconds to let the surplus water drained off. After the corn is put in, another plate is inverted over the sand to exclude the light and to prevent excessive evaporation. The Geneva germinator is a very sat-

isfactory apparatus, both for giving good results and for convenience in handling. Where much testing is to be done, it is advisable to obtain one of these germinators.

The use of too small a number of seeds in germination tests should be guarded against when accuracy is desirable. The use of one hundred kernels of corn, as is sometimes recommended, may give a fair idea of the germinating power of the seed but it is not accurate. Extended experimentation by careful investigators has shown that when fewer than three hundred to four hundred seeds are tested, the "coefficient of error" is too great to admit of accurate results. Furthermore, the taking of but two or three kernels from a single ear is quite inadequate. Two entire rows, taken from opposite sides of the ear will be much more satisfactory.

It is not expected, nor indeed is it desirable, that the time and

care required for accurate scientific work, be taken when seed is to be tested for ordinary use. However, from five to ten kernels should be taken from each ear, and a large number of ears should be taken. If, from ten bushels of seed corn, one hundred ears be selected and ten kernels be selected from each ear, the results ought to be satisfactory enough for ordinary purposes.

3. Effect of Thickness of Planting. - The amount of space that is allowed for a stalk of corn to grow in affects the whole plant very materially. If the plant has plenty of room, it can the easier obtain the necessary plant food from the the soil, and the broad green leaves will spread out in the sunshine to receive the carbon and oxygen from the atmosphere and the heat from the rays of sunlight. The whole plant is healthy and vigorous and the seed which it produces partakes of this vigor. On the other hand, if

the plants are crowded together, the roots interfere with each other, forming a dense mat, and are unable to obtain a sufficient amount of plant food. The shoots, also, are crowded and as they are compelled to overreach each other in their struggle for light and air, they grow very tall and slender while the lower leaves are overcome. The plant cannot be vigorous under such conditions, but is a prey to insects and fungi, whose attacks it might otherwise withstand. The seed of such a plant is necessarily weakened, and if it germinates at all it can never produce strong, healthy plants.

Although better seed may be produced when plants are not too close, the mistake might be made of planting too far apart. The individual plants would produce excellent seed so far as health and vigor are concerned, but there is another factor to be considered. Corn, in common with other plants

is sensitive to environment, and adapts itself to the prevailing conditions. This process is slow but is constantly going on. If one should give his corn considerably more room than is usually given, as it would become adapted to a larger space and would not do so well when planted closer together. Seed corn should be produced under conditions similar to those under which it is to be planted.

4. Effect of Age of Seed.- If seed corn is properly dried as soon as mature, and is kept in this condition, it should preserve, for several years, its power to germinate. After two or three years, this power rapidly diminishes. The corn grower is interested in securing seeds having the greatest possible vigor, in order that he may run as little risk as possible in raising a crop. For this reason, one year old seed should be used if possible; unless, for some reason, that crop

was not as good as the succeeding crop, in which case the two-year-old seed should be used. It is not best to use seed corn over two years old.

Chapter V.

General Principles of Planting.

1. Preparation of the soil.- Upon the thorough preparation of the soil for the reception of the seed, depends to a great extent, the character of the crop produced. The condition of the soil affects the availability of the plant food and of the moisture content of the soil. A compact or a cloddy soil hinders the development of the roots, thus making it impossible for the root hairs to come into contact with the soil particles to a degree sufficient to obtain enough plant food for the plant. The plant food which the root hairs absorb is held in solution in the film of water which surrounds the soil particles. If the soil is in a friable condition the roots can easily penetrate it

and the root hairs are brought into contact with myriads of minute soil particles, around each of which is held a store of plant food. This condition of the soil is favorable to the reception of rainfall, whereby moisture is provided for the solution of the plant food in the soil and for a carrier in the tissues of the plant.

To secure the results mentioned above, a soil should never be plowed when it is too wet. If it turns over with a shiny surface and does not crumble, it is too wet. If it is plowed at this time, the texture of the soil will be injured. If a soil does not get dry enough to plow in time for a corn crop, it had better lie fallow than to run the risk of being injured for several years.

After the soil is turned with the plow, it should be thoroughly pulverized, both disk-harrows and smoothing harrows being used if necessary. If, on account of a

in great want of organic matter or for any other reason the soil is so loose that capillary action can not proceed properly, compacting the soil with a heavy roller will be found beneficial. To prevent excessive surface evaporation the roller should be followed by a smoothing harrow, which will make a mulch and hinder the capillary action near the surface.

2. Time of Planting. The best time to plant corn varies considerably with the meteorological and soil conditions. As corn is of tropical origin, it still preserves, to a considerable extent, its love of warmth. It would not be best to plant corn before the spring sunshine had warmed the soil. As some springs are later than others, the proper temperature of the soil is consequently delayed. The character of the soil influences the rapidity with which the required temperature is attained.

a light, sandy soil will warm up much more quickly than a heavy clay soil. It is evident, then that the farmer must use his judgment in determining the proper time to plant. Experiments in the "corn belt", near the fortieth parallel, indicate that, in general, in the average spring and on soil well adapted to corn, the second week in May gives the best results, although corn planted any time in May will usually do well. It is the usual practice to plant a little earlier in sod than in land that was tilled the previous year. By this means the ravages of the cut worms are not so great. The average advance of the season is about one-fourth of a degree of latitude daily. A variation from the time given above should be made when corn is to be planted at a considerable distance from the above parallel. One hundred miles north would make a difference of about one week, making the time about the third week in May.

3. Effect of Thickness of Planting.- The quantity of seed which the corn-grower may most advantageously plant upon a given area depends upon several factors, namely, the character and treatment of the soil, the amount of moisture in the soil, and the purpose for which the crop is to be used.

The character of the soil is of prime importance because in the soil is a part of the food material from which the plant is built up. The soil must either contain a sufficient amount of the needed plant foods, or what is lacking must be supplied in the form of manure or commercial fertilizers. On the character of the soil depends its capacity for holding water, and the degree to which it may be aerated. On the manner in which the seed bed is prepared and in which the crop is cultivated depends both the availability of the plant food and the water content of the soil.

The amount of moisture in the soil is originally dependent upon the rainfall, and over this the farmer has no control. This factor must therefore remain an uncertain quantity, so far as the rainfall of the crop season is concerned. The only thing that one can go by in this particular is the probable rainfall, judging from the weather records of the past. The amount of moisture already in the soil, however, can be conserved by proper tillage.

The farmer determines for himself the purpose for which the crop is grown. Whether he desires a maximum of grain without regard to the quantity of stover, or a maximum of stover with little grain, or a crop in which both grain and stover are desired, is for him to decide.

Let it be granted that the soil is naturally well adapted to the raising of corn, the necessary plant food being supplied if lacking;

that the soil is put into proper condition for the reception of the seed and is properly cultivated; and that the moisture content of the soil is sufficient for a maximum crop. It will seldom, if ever, be the case that all these conditions are found at the same time, but the results of a series of experiments no doubt point in the right direction.

If a maximum yield of grain is desired, the area per plant must be less than is usually allowed. Corn is usually planted in rows three and one half feet apart, with the hills three to three and one half feet apart in the rows. The average number of kernels per hill is about three. This allows three to four square feet per stalk. Careful tests have shown that about two square feet to the stalk produces the most grain. If the rows are three and one half feet apart, the hills must be about six inches apart with one kernel in each, or twelve inches apart with two kernels in each.

If the hills are equidistant from each other in two directions, the best results seem to be given when the hills are from two to two and one-half feet apart. When corn is planted so closely as this, however, the ears are rather small. If the crop is to be fed as fodder, small ears are rather an advantage than otherwise; but if it is to be husked, the increase in expense of handling will offset the increase in yield. It would probably pay, in the majority of cases, to plant the hills three feet apart each way, and to plant two to three kernels to the hill. If a large quantity of stover is desired, the hills should be quite close, allowing about one and one half square feet to the hill, with three kernels to each hill. This will make a large quantity of material for the silo. There is a fair quantity of grain, but the ears are very small. The stalks are small in diameter and are difficult to handle without a corn harvester. If the hills are planted eighteen to twenty-four inches apart, with

three to four kernels in each hill, the size of both ears and stalks will be increased, while the total yield is very little, if any, reduced.

4. Depth of Planting. The depth to which corn should be planted is important, but here, also, the judgment of the farmer must determine the procedure. The kernels must be deep enough to obtain moisture sufficient for germination; but if it is in the presence of too great an amount of moisture, germination will be hindered because of an insufficiency of oxygen. It is at once evident that much depends upon the character and condition of the soil and upon the prevailing meteorological conditions. If the soil is quite porous and the water readily drains out, the required moisture will be farther below the surface than in a [illegible] drained soil. If the soil is not well pulverized, but [illegible]

-cloddy condition, the moisture content is very scant in the surface soil. Finally, if the spring is dry and windy, the moisture will be present in the surface soil in very limited quantities. It is evident that where one or more of the above conditions prevails, the kernels must be planted deeper than is ordinarily necessary. On the table lands of the upper Colorado, it is necessary to bury the kernels twelve to fourteen inches deep, as the soil is sandy and rain seldom falls. Under conditions favorable to corn growing, a depth of two to three inches has given the best results, as a rule. If the spring is wet, one inch, or even less, is deep enough, but the chief difficulty in planting so shallow is the covering of the kernels unless the work is done by hand, which is impracticable when corn is grown on a large scale. Ca-

should not be planted deeper than three inches unless it is necessary on account of scarcity of moisture. The theory that deep planting gives the stalks a firmer hold has support in the facts. If a kernel is planted one inch deep, it will throw its primary root downward, and send out secondary roots nearly horizontally. If it is planted six inches deep, the same thing, approximately, occurs. The shoot, however, must struggle upward through six inches of soil before it reaches the light. Then, from one to two inches below the surface, a whorl of secondary roots is thrown out at one of the nodes, and in a short time the part of the plant below that point sloughs off. The result is that the plant is fixed no more firmly than when the planting is one inch deep, while both time and energy have been lost in its struggle to reach the surface.

Part Two.

Experimental Work.

Introduction.

Under the supervision of the Department of Agronomy in the College of Agriculture of the University of Illinois, the writer carried on a field experiment, during the summer of 1902, in methods of planting Indian corn; the special problem being to determine what effect the thickness of planting has upon the yield. The writer believed that, in general more space was allowed to each plant than was necessary to attain the best results, considering the improved methods employed in the tillage of corn. This was the principal line of work carried on, but a subordinate line was carried on early in the

season in conjunction with a fellow student, F. E. Enteen. This was a test to determine the effect of the depth of planting upon the germination of corn and several other common grains.

In the Department of Botany in the College of Science, the greater part of the University year has been spent in the microscopical study of the corn kernel. This was undertaken for the purpose of demonstrating the anatomical structure, and the process of double fertilization. This work has not yet been completed, but a large quantity of material is still on hand for examination. For this reason, but little data from this work has been incorporated into this thesis.

Chapter I.

Meteorological Data.

Precipitation at the Urbana Station.

Annual		Average by Months		1902 by Months		Wettest Months			Driest Months		
	"		"		"			"			
1890	30.3	Jan.	1.89	Jan.	.62	Jan.	1898	4.77	Jan.	1900	.17
1891	26.7	Feb.	2.06	Feb.	1.48	Feb.	1893	4.48	Feb.	1895	.50
1892	39.0	Mar.	2.73	Mar.	1.69	Mar.	1898	7.76	Mar.	1895	.70
1893	32.3	Apr.	2.95	Apr.	2.11	Apr.	1893	7.68	Apr.	1889	.61
1894	23.7	May	4.05	May	2.61	May	1892	7.86	May	1897	1.80
1895	29.1	June	4.21	June	10.98	June	1902	10.98	June	1893	1.55
1896	35.9	July	3.23	July	4.07	July	1896	7.87	July	1893	.59
1897	33.8	Aug.	2.84	Aug.	9.80	Aug.	1902	9.05	Aug.	1893	1.06
1898	48.7	Sept.	2.53	Sept.	4.99	Sept.	1896	5.84	Sept.	1893	.31
1899	29.6	Oct.	2.01	Oct.	2.10	Oct.	1899	5.01	Oct.	1896 1897	.42 .42
1900	34.0	Nov.	3.15	Nov.		Nov.	1891	5.58	Nov.	1901	.31
1901	28.6	Dec.	1.91	Dec.		Dec.	1895	5.71	Dec.	1890	.05
Av.	32.6+			Total							

Chapter II.

Effect on Yield of Thickness of Planting.

1. Location of Experiment.– The experiment in thickness of planting was conducted on the experiment grounds of the University of Illinois, about half way between the astronomical observatory and the horse barn. It was located on a knoll and had very good drainage. The entire area covered by the experiment was about seventeen rods from east to west by about eight rods from north to south.

2. The Character of the Soil.– The soil is the ordinary black loam of the Wisconsin Glaciation. The subsoil, found sixteen to eighteen inches below the surface, is a yellow clay containing sand and gravel. The soil is very well adapted to corn.

3. The Treatment of the Soil. This ground had been broken in the fall of 1901. Preparatory to planting, it was thoroughly pulverized with a disk harrow. No record has been kept of the manure that has been applied in the past, but it has received very little, if any, treatment in this respect.

4. Time and Manner of Planting. The planting was begun May 22nd and finished May 29th. It was done by hand, hoes being the only implements used. The kernels were covered with about two inches of dirt. There were fifty variations in all requiring fifty plots. Each plot was one rod wide by two rods long. The plots were arranged in three east and west rows. Passageways four feet wide were left between the rows of plots.

5. Time and Manner of Cultivating. The implements used in cultivating the corn were a one-horse

weeder, a one-horse cultivator, a one-horse hand-harrow, and a two horse cultivator. The weeder and the harrow were used while the corn was small, and the cultivators were used later. The cultivation was rather shallow. The ground was cultivated as often as was necessary to keep down the weeds and to keep the soil in good condition. From June 13 to to July 12th the plots were gone over five times, including the work done with the weeder and the harrow.

6. Time and Manner of Harvesting. The first part of the fourth week in October, the corn was cut and shocked by hand. After a month and a half, the corn was husked out and the weights of stover and grain were taken.

7. Table of Data:

Plot No.	Inches between Hills.	Sq. ft. per Hill.	Grains per Hill.	Ten Average Plants.		Yield from Plot.	
				Stover.	Ears.	Stover.	Corn.
1.	42 × 42	16	6	4 lbs.	5 lbs.	61 lbs.	60 lbs.
2.	"	"	5	5 "	6 "	72 "	68 "
3.	"	"	4	4½ "	5½ "	[illegible]	53 "

4.	48×48	16	3	5½ lbs.	7 lbs.	37 lbs.	51 lbs.
5.	"	"	2	7 "	6 "	45 "	48 "
6.	45×45	14 1/16	6	4 "	5 "	45 "	52 "
7.	"	"	5	4 "	6 "	52	54
8.	"	"	4	4½ "	6½ "	51	58½
9.	"	"	3	5 "	7 "	41	47
10.	"	"	2	6 "	7½ "	32	34
11.	42×42	12¼	5	4 "	5 "	51	55
12.	"	"	4	4½ "	6 "	57	57
13.	"	"	3	4½ "	6½ "	47½	61½
14.	"	"	2	5 "	7 "	34½	44
15.	39×39	10½	5	5 "	5 "	60	57½
16.	"	"	4	5 "	5 "	62	61
17.	"	"	3	4 "	5½ "	54½	69
18.	"	"	2	2½ "	3½ "		
19.	36×36	9	5	4½ "	5½ "		
20.	"	"	4	4 "	5 "		
21.	"	"	3	4¼ "	5¾ "		
22.	"	"	2	3¾ "	5¾ "		
23.	33×33	7 9/16	5	2½ "	3 "	72	55
24.	"	"	4	2¾ "	3½ "	62	59
25.	"	"	3	3½ "	3½ "	56	64
26.	"	"	2	5¾ "	6¼ "	50	64½
27.	30×30	6¼	4	2½ "	3 "	60	51
28.	"	"	3	2½ "	3 "	47	58
29.	"	"	2	3¾ "	4½ "	37	49
30.	"	"	1	4 "	6 "	28½	32

31.	27×27	5 1/16	4	2½ lbs.	9 lbs.	[illegible]	[illegible]
32.	"	"	3	2½	7½ "	64	69½ "
33.	"	"	2	2¼ "	8 "	52½ "	73½ "
34.	"	"	1	3¾ "	5½ "	32	86½
35.	24×24	4	4	1¾ "	2½ "	[illegible] "	[illegible]
36.	"	"	3	2½ "	2½ "	74 "	47½
37.		"	2	3 "	3½ "	61	50½
38.	"	"	1	4½ "	5½	41 "	57½
39.	21×21	3 1/16	4	2½	3 "	110 "	43 "
40.	"	"	3	2¼	3	91½ "	42 "
41.	"	"	2	3 "	3½ "	72 "	62½
42.	"	"	1	3 "	5 "	47 "	54 "
43.	18×18	2¼	3	2½ "	1¼ "	114 "	53½
44.	"	"	2	1¾ "	3¼ "	87 "	44½ "
45.	"	"	1	3 "	4 "	63 "	56 "
46.	15×15	1 9/16	3	1¼ "	1¼ "	128 "	62¼ "
47.	"	"	2	1¾ "	2¾ "	104½	42 "
48.	"	"	1	2¼ "	2¾ "	78 "	58½ "
49.	12×12	1	2	1½ "	2 "	108 "	45 "
50.	"	"	1	2½ "	3½ "	90 "	59½ "

8. Conclusions drawn from the above data.

(a) Corn can, with profit, be more closely planted than it is usually planted, provided the conditions are similar to those under which

the above test was made.

(b) In this experiment the largest yield of ear corn was obtained on plot 33, where the hills were 27 inches apart and where 4 grains were planted in each hill. The distance between hills would probably have to be increased somewhat in the ordinary year, as the rainfall during the growing period was much greater this year than is ordinarily the case. Probably 30 or 33 inches would be about right.

(c) The highest yield of stover was from plot 46, where the hills were 18 inches apart with 3 grains planted to the hill. This plot also gave the highest total yield of stover and corn.

On pages 92 to 104 are photographs illustrating the effect on the growth of the stalk of the different rates of planting. A typical hill was selected from each of the fifty plots. The tassels were just appearing.

Chapter III.

Effect on Germination of Depth of Planting.

The experiment to test the effect of different depths of planting on germination was conducted several rods north of the experiment on the thickness of planting. The soil was similar to that described above but lay a little lower. The seed was planted at depths varying from one half inch to twelve inches as shown in the table below. It must be remembered that there was an abundance of moisture in the soil so that shallow planted seeds would have a better chance to germinate than if it were dry; while very deeply planted seeds would be [illegible]

be [illegible]. The following table gives the results with the [illegible] only. [illegible] planted May 16th, twenty seeds being planted in each row.

Table of [illegible] etc.

	*½	1	2	3	4	5	6	8	10	12		
May 21.	†14	17	16	10								
22.	1	1	2	8	2							
23.	0	0	0	1	4							
24.	4	0	0	0	5	9	2					
25.	0	0	0	0	3	3	5	1				
27.	0	0	0	0	2	1	0	0				
28.	0	0	0	0	0	0	2	1				
June 2.	0	0	0	0	0	0	0	2				
Total	19	18	18	19	16	13	12	4	0	0		

* Horizontal row of numbers represents depth in inches.

† Vertical rows of numbers represent the number of plants coming up each day.

Bibliography.

The works listed below constitute a very small part of the literature bearing upon the subject treated in this thesis. It is hoped that it is typical of the literature that may be found, however, in the United States. No attempt has been made to include any of the great mass of foreign works.

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(b) Experiments with Corn, Bulletins 42, 46.
(c) Corn Crossing. Bulletin 21.
(d) Cost of Production of Corn, Bulletin [illegible]
(e) The Chemistry of the Corn Kernel. Bul. 53.
(f) Seed Corn and Some Standard Varieties for Illinois, C. [illegible]
(g) Corn Experiments in Illinois, Circular 66.
(h) Investigation of Illinois Soils, Circular 64.
(i) Methods of Maintaining the Productive Capacity of Illinois Soils, Circular 68.

The majority of our experiment stations have publications on Indian corn. A number of those in the "Corn Belt" have a large amount of published matter. The list is too long to reproduce here. The entire list may be found in the indexes of the volumes of the U. S. Experiment Station Record.

Plate I.

93.

Plate II.

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Plate III.

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Plate IV.

Plate V.

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Plate VI.

Plate VII.

Plate VIII.

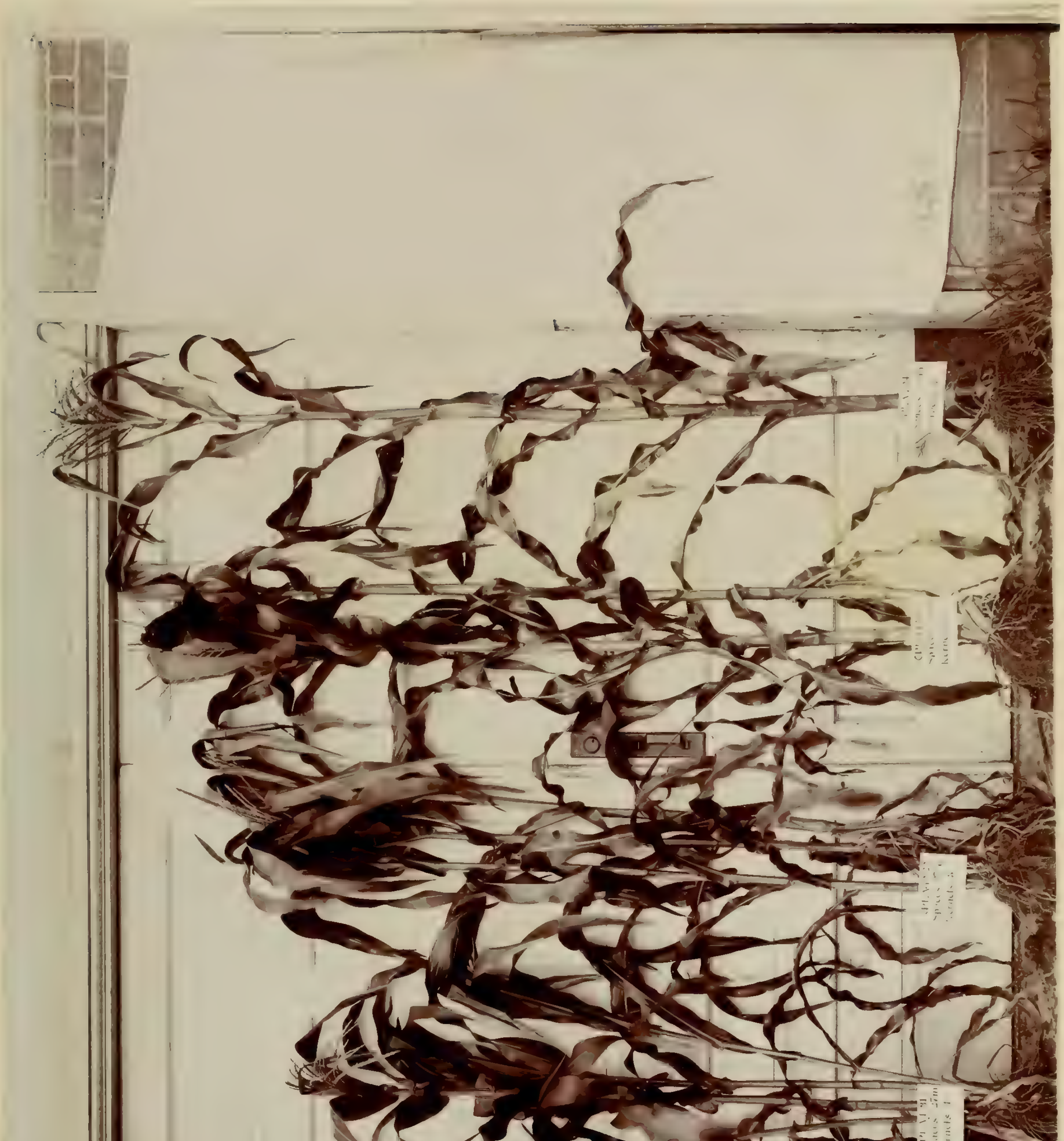

Plate IX.

Plate X.


PLAT 39.
Spaces. 21 in.
Kernels. 4.
(PLAT 40.)
Spaces. 21 in.
Kernels. 3.
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Plate XI.

Plate XII.

Plate XIII.

Plate XIV.

Plate XV.